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Fractionated edible tallow shows promise as cocoa butter replacement

by J. W. Hampson, F. E. Luddy, and H. L. Rothbart

The confectionery industry has long sought a replacement for one of its most expensive ingredients, cocoa butter. The U.S. Department of Agriculture hopes to develop a good cocoa butter replacement as well as of other confectionery fats from edible tallow which is a readily available United States commodity. For such a cocoa butter replacement, the fat should be solid at room temperature, but melt at body temperature. It should also have snap, mould release, gloss, no off-flavors or odors and ideally should be compatible with cocoa butter. Such a fat can be obtained from edible tallow.

Edible tallow is a high-quality fatty byproduct of the beef industry and is produced for human consumption. It differs from inedible tallow in that it must be prepared under strict sanitary conditions and government inspection. The United States is the world's largest tallow producer. In 1974 total world tallow production was 10.1 billion pounds; of this the United States produced 55.6 per cent. In the world tallow export market, the United States is even more dominant, exporting 2.3 billion pounds, which is 64.6 per cent of the 3.5 billion pounds available in international trade. Tallow ranks second only to soybean oil in the amount of fats and oils produced in this country. Projections for 1980 indicate that United States tallow production will be about seven billion pounds — a 40 per cent increase over that which is currently available.

From 1950 until 1972, inedible tallow sold for 4-11 cents a pound with edible tallow demanding a premium of two to three cents a pound. In August 1975, published prices per pound were $1.17 and $.27 for cocoa butter and edible tallow respectively. The situation is then that the United States is exporting a low price fat and at the same time importing a premium priced fat.

Edible tallow is a triglyceride mixture separated from meat tissue by rendering. Its composition is not too different from other well-known fats. For example, the major fatty acids of tallow are the same as those of palm oil and cocoa butter. Table 1 shows fatty acid composition of tallow and some fats and oils of interest to the confectionery industry. Notice that in tallow the three main fatty acids, palmitic (27 per cent), stearic (14 per cent), and oleic (42 per cent) are also cocoa butter's main fatty acids. Palm oil also has the same fatty acids as cocoa butter. "Coberine," one of the well known substitutes for cocoa butter, is believed to be fractionated from a combination of palm oil with some other minor oils including shea butter. Coconut oil and palm kernel oil, the so-called lauric oils, have entirely different fatty acid composition which accounts for their incom-

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Table 1 - Principal Fatty Acids, Wt. Per cent

Fatty Acid	Cocoa Butter	Tallow[a] Hard Butter	Beef[b] Tallow	Palm Oil	Coconut[c] Oil	Palm Kernel[c] Oil
Lauric	—	—	—	—	48	50
Myristic	1	3	4	1	18	16
Palmitic	24	32	27	45	8	8
Stearic	35	26	14	5	3	3
Oleic	38	33	42	39	7	12
Linoleic	2	1	2	9	2	3

a *Plus 2 per cent palmitoleic and 2 per cent margaric acid.*
b *Plus 2 per cent myristoleic, 5 per cent palmitoleic, and 2 per cent margaric acid.*
c *Plus 4-8 per cent caprylic and 4-6 per cent capric acid.*

Table 2 - Triglyceride Composition, Wt. Per Cent

Triglyceride Type	Cocoa Butter	Edible Beef Tallow	Tallow Hard Butter
Trisaturated	2	8	2
Disaturated	84	40	90
Monosaturated	12	40	8
Triunsaturated	2	12	—

Table 3 - Per Cent Solid by DSC

Temp. °C	South American Cocoa Butter	African Cocoa Butter	Tallow Hard Butter
16	82.1	90.7	93.0
20	47.2	65.0	59.7
24	16.6	27.1	29.5
28	1.2	1.6	11.7
32	0	0	1.5
36	0	0	0

about the authors

This article is based upon an address entitled, "Confectionery Fats from Fractionated Edible Tallow," presented by J. W. Hampson and co-authored with F. E. Luddy and H. L. Rothbart, all of the Eastern Regional Research Center, Agricultural Research Service, U.S. Department of Agriculture, Philadelphia, Pa. It was given at a meeting of the New York Section of the American Association of Candy Technologists.

patibility with cocoa butter.

The tallow hard butter (prepared by solvent fractionation and discussed below) does have the same fatty acids as cocoa butter. Palmitic, stearic, and oleic acids make up 97 per cent of cocoa butter's composition and they make up 91 per cent of the tallow hard butter. In palm oil these three fatty acids make up 89 per cent of the total but the disproportionate ratio of stearic to palmitic makes a fat that is not similar to cocoa butter. Coconut oil and palm kernel oil contain only 18 and 23 per cent respectively of these three fatty acids. In addition they contain mostly lauric acid which is not found in cocoa butter except possibly in trace amounts.

Fatty acid composition alone does not give the whole story. Arrangement of the fatty acids in the glyceride molecule to make different types of glycerides is very important to the final physical characteristics. In Table 2 it can be seen that the triglycerides which make up cocoa butter are primarily disaturated (84 per cent). Tallow contains 40 per cent disaturates. By separating out these glycerides from tallow, a good cocoa butter replacement might result.

In the past, a different approach has shown that tallow might make a good starting material for the production of confectionery fats. The literature indicates that Japanese and Russian scientists are developing confectionery fats from tallow. The tallow hard butter as shown in the third column, is primarily disaturated. And because of the fatty acid composition, which is similar to cocoa butter as shown in the previous table, it must contain triglycerides which are similar to cocoa butter. Also its trisaturated and monosaturated glycerides are about the same amount as those found in cocoa butter. The thermal properties of this tallow hard butter and others similar to it indicate that they would make good confectionery fats.

By using a tallow fractionation scheme evolved from a background in fat composition studies carried out in the 1940's, it was possible to prepare a number of different fractions of the tallow hard butter in the tables. Essentially the scheme consists of a four-step acetone crystallization procedure. Solvent ratios are varied from 10/1 to 25/1 and temperatures of crystallization range from 0°C to 25°C. This process, which already has been scaled up to batches of 100 and 350 pounds, yields two hard fractions, two liquid fractions, and a plastic solid fraction which can be used as a hard butter. In practice the two hard fractions are combined to yield 15 per cent and the two oil fractions are also combined to yield 65 per cent.

Thus, three products result as can be seen in Fig. 1. At room temperature, the edible tallow appears solid, but it is actually a semi-solid, slightly off-white fat. Two of the products are white solids. Most of the color is carried through and stays with the oil. The solid fraction is high melting (60°C) and contains about equal amounts (36 per cent) each of palmitic and stearic acids with a minor amount of oleic acid (18 per cent). The liquid fraction is high in oleic (55 per cent), with one-third saturated acids, palmitic being three times greater than stearic. The plastic solid fraction is one-third unsaturated acids, mainly oleic (33 per cent) which gives it a similarity to the composition of cocoa butter although the palmitic to stearic ratios are reversed. The plastic solid melts in the range of cocoa butter.

Edible tallow is a reasonably uniform ... different products from different sources of tallow were consistent. Examination of the various tallows with thermal analysis (Differential Scanning Calorimetry DSC) showed there was not much difference in the thermal profiles.

DSC was also used to investigate the thermal properties of the tallow fractions, especially the similarity in melting behavior of the plastic solids to cocoa butter. These data are shown as DSC thermal profiles in Fig. 2. The thermal profiles are melting profiles, obtained by heating the tempered solidified samples at 10°C/min. Sample melting is characterized by the large downward deflection of the curve. Our tallow products have melting curves similar to commercial hard butters and in some cases the tallow thermal profiles are almost identical to those for cocoa butter.

Fig. 2 shows that a range of confectionery fats melting from slightly below 30°C to those melting up to 60°C can be obtained by modifying the fractionation scheme slightly and also by blending the three main products in different proportions. The narrow melting range of these fats is comparable with commercial hard butters. One of the samples (B) has a melting profile almost identical to cocoa butter.

Table 3 shows a comparison of the per cent solids of two different cocoa butters and a tallow hard butter. This data was obtained using a DSC procedure with a heating and cooling

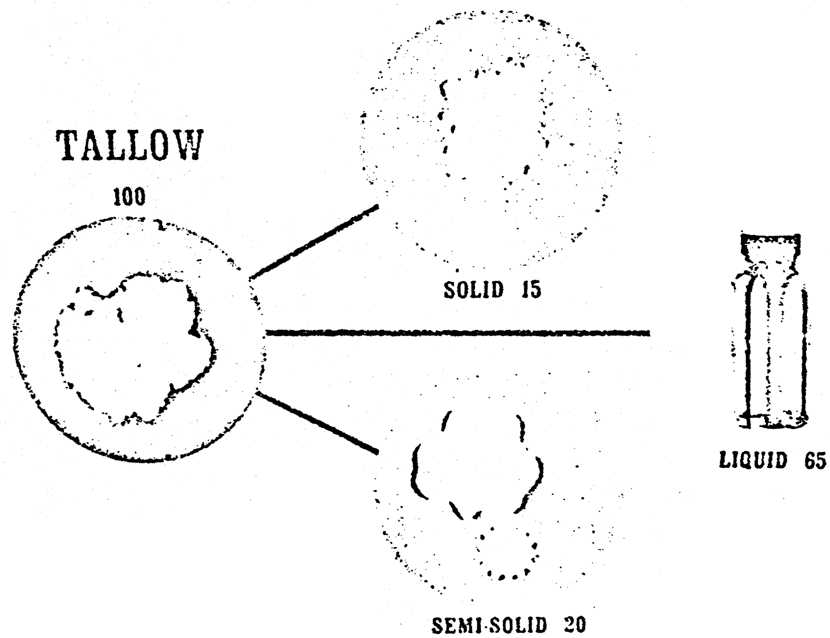

Figure 1. Fractionated edible tallow products.

program used by one of the candy companies.

Fifteen commercial hard butters were examined and their DSC melting profiles were compared with the tallow hard butters. Some of their profiles were not very different from those shown in Fig. 2. Generally, the hard butters melted higher than the tallow cocoa butter replacement, but they also melted higher than cocoa butter. Seventeen tallow blends were prepared to be compared with these hard butters. In Fig. 2 (A, C, D) are tallow blends. Thus, a number of confectionery fats could be made available for cookie producers who require high melting fats.

Other tests, such as storage at various temperatures and thermo-mechanical analysis, were performed on tallow hard butters and compared with cocoa butter and hard butters.

Perhaps the best test for a cocoa butter replacement is to mix it with cocoa butter and observe the change in melting profile. Fig. 3 shows 50/50 mixtures of cocoa butter with two different tallow hard butters and also a 20 per cent cocoa butter and 80 per cent mixture. The melting profile is sharp in each case and melts in the region expected for cocoa butter.

In a test coating, the tallow confectionery fat represents 93 per cent of the total fat with the remaining seven per cent coming from the cocoa butter in the cocoa powder. This coating had excellent flavor, as well as gloss, snap, and mould release. The coating was cycled at 86°F for eight hours followed by storage at 68°F for 16 hours. After four cycles the coating was still in good condition and hadn't bloomed.

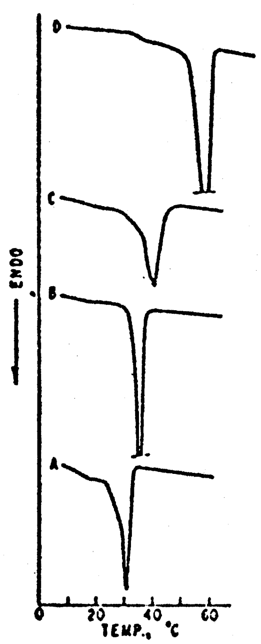

Figure 2. DSC melting profiles of tallow hard butters. (A,C,D) tallow fraction blends, (B) unblended tallow fraction.

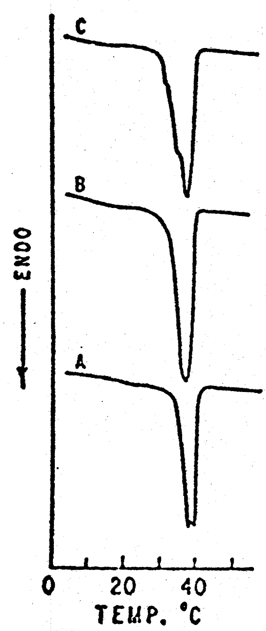

Figure 3. DSC melting profiles of cocoa butter plus tallow hard butter mixtures. (A) 20 per cent cocoa butter plus 80 per cent tallow butter b (B) 50 per cent cocoa butter plus 50 per cent tallow butter b (C) 50 per cent cocoa butter plus 50 per cent tallow butter e.

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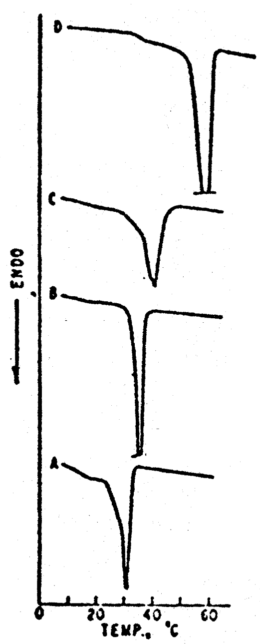

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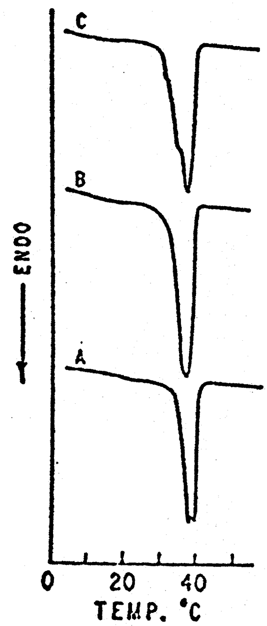

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